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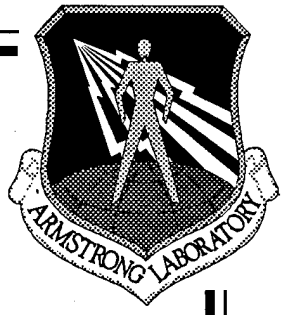

INFLUENCE OF LARGE VOLUME PHLEBOTOMY ON COMPENSATORY TRACKING PERFORMANCE IN RHESUS MONKEYS

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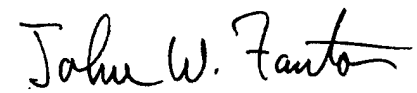

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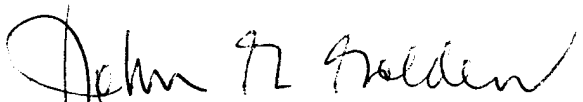

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13. ABSTRACT *(Maximum 200 words)*

In the biomedical research community, veterinarians charged with the clinical care of nonhuman primates occasionally are called upon to make judgments on the issue of blood volumes, blood sampling criteria, and the effects of phlebotomy on research results. The clinician must balance on a fine line when allowing investigators to perform either frequent small volume phlebotomies, or single large volume phlebotomies. Some large primate colonies allow 10 ml/kg of whole blood to be removed as single withdrawals no more often than once per month, while other institutional policies dictate smaller volumes and less frequent sampling intervals. Since it has already been proven that rhesus monkeys survive single, large volume phlebotomies without adverse effects, a study was designed to determine the effects of such large volume phlebotomy on the performance of a demanding sensorimotor task. This task, the Primate Equilibrium Platform (PEP), is sensitive to changes in central nervous system sensorimotor integration, but does not necessarily involve complex cognitive functions. It was found that PEP was unaffected after single, large volume (10 ml/kg) phlebotomy in rhesus monkeys.

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Introduction

Nonhuman primate medical care has evolved into an exacting art form since the inception of that specialty within the veterinary medical community. In the biomedical research community, veterinarians charged with the clinical care of nonhuman primates occasionally are called upon to make judgments on the issue of blood volumes and blood sampling criteria. The clinician must balance on a fine line when allowing investigators to perform either frequent small volume phlebotomies, or single large volume phlebotomies. The dilemma continues to be: What is safe for the nonhuman primate and yet will provide investigators with adequate blood volumes to perform their studies? Recent work has shown that rhesus monkeys can readily survive phlebotomy of 10% of total blood volume weekly over 11 weeks without substantial ill effects (16). Although some hematologic and clinical laboratory parameters were decreased in this study, mortality was not affected (16). Institutional policies governing this issue are, in many instances, based on anecdotal information and opinions rather than the results of objective studies. Some large primate colonies allow 10 ml/kg of whole blood to be removed as single withdrawals no more often than once per month (20). However, other institutional policies dictate smaller volumes and less frequent sampling intervals (21,22).

The key question remains a clinical one. Prior studies indicate that up to 37% of the blood volume of young male rhesus monkeys can be removed acutely without ill effects clinically (15). Also, they can sustain weekly phlebotomy of up to 24% of total blood volume, although iron supplementation or other special nutritional support is required to prevent continuous reductions in packed cell volume and hemoglobin (15).

This issue is of continuing importance for the Armstrong Laboratory veterinary staff, who are frequently faced with decisions concerning donor animals. Since it has already been proven that rhesus monkeys can readily survive large volume blood loss, both acutely and chronically, a study was designed to determine the effects of such large volume losses on the performance of a demanding sensorimotor performance task. This task, the Primate Equilibrium Platform (PEP), is sensitive to changes in central nervous system (CNS) sensorimotor integration, but does not necessarily involve complex cognitive functions. The PEP task is a non-human primate model that the Air Force has used for more than 20 years to measure the effects of hazardous environments on performance. Among the environmental hazards that have been studied are ionizing (2,19,25) and nonionizing (23) radiation, chemical warfare agents (4-5,7-8), and chemical warfare defense pretreatments and/or therapies (6,10,17-18,24). Since the PEP task is physically demanding, as well as being sensitive to changes in both central and peripheral neural function, it seems likely to be sensitive to any subtle debilitating effects of excessive blood loss.

Methods

Twelve adult male rhesus monkeys (6.8 - 10.3 kg body weight) were used in this study. All were trained in the Primate Equilibrium Platform (PEP) task, which has been previously described (4-7,8,10-12,18,23-24). During a single phlebotomy, 10 ml/kg of

whole blood was withdrawn via femoral venipuncture. The monkeys were then returned to their cages for one hour prior to the first testing program. Prior to phlebotomy, the PCV was determined for each monkey to ensure that none of the subjects were anemic prior to the experiment. Packed cell volumes ranged from 42-46%, well within the normal range for the AL colony.

One-hour PEP testing sessions were performed at 1 hour and 1, 2, 3, 7, 15, and 30 days after phlebotomy.

Measurement of PEP Performance

The PEP task is a continuous compensatory tracking task that measures the ability of a monkey to compensate for unpredictable perturbations in pitch induced by a filtered random noise signal. The experimental subject sits in a chair that rotates about the pitch axis. Pitch angle of the chair is measured by a linear potentiometer coupled to the rotating shaft. The potentiometer and associated A-to-D converter are calibrated by reading in potentiometer voltages at 5 degree intervals over a 40 degree range. The computer then fits a line to the sampled values using a least-squares procedure to determine a factor for converting input voltage to chair position in degrees. Repeated calibrations produce values that vary from one another by less than 1%. Platform position (angle in degrees) is measured 10 times per second, and the standard deviation (σ) of all the scores for each 2.5-min epoch, i.e., 1500 data points, is the metric for PEP performance. In the absence of joystick input, the random external input produces a large variation in platform position (σ of ~12°, with the largest excursions near the platform's limits of motion: ±40°). Well-trained subjects reduce this variation to a σ of ~2.5-4.0°. Performance is motivated by electric shocks (0.10 s at 1-Hz repetition rate, 5 mA maximum current) delivered to the tail whenever the chair platform deviates from the horizontal by more than 15°. For each subject, tail-shock intensity is adjusted to the minimum level required to maintain motivated performance in baseline tests (well-trained subjects receive very few tail shocks, <1 shock/hour on average). Subjects perform this task for 60 min.

RESULTS

There were no observed clinical effects from the phlebotomies. All monkeys resumed normal activity after placement in their cages, displaying no sign of syncope, weakness, or other indicators of hypotension. Normal behavior for each monkey was observed both during and immediately after phlebotomy. Normal displays of aggression and dominance were observed.

There were no significant effects on PEP performance from the phlebotomy procedures. Figures 1 -12 show the performance of each of the subjects. The upper panel of each figure shows a representative pre-phlebotomy test session (baseline) and the statistical upper limit of normal performance. If the data from more than one test epoch per session exceeds this limit, we would consider the performance to be subnormal ($p < .05$). The data from individual test sessions 1 hour to 30 days post

phlebotomy are also shown in the upper panel for each monkey. Of the 84 post-phlebotomy sessions (12 animals X 7 sessions), only 2 met this stringent statistical criterion for subnormal performance. One of these 2 subnormal sessions occurred 1 hour after phlebotomy (monkey 570Z). The other occurred 30 days after phlebotomy (monkey 592Z). The upper limit shown in the figures is the performance level above which a single data point per session would occur by chance in 5% of all test sessions. We requires that at least 2 points fall above this level in a session before we consider the performance to be subnormal. This would occur by chance in approximately 2.5% of test sessions. For 84 test sessions, 2.5% = 2.1 sessions. It should not, therefore, be surprising that 2 sessions met this criterion. The lower panel of each monkey's graph shows the variation in PEP performance (mean and standard deviation) over time after phlebotomy. The mean and standard error for the 24 epochs in the test sessions shown individually in the upper panel are plotted as a function of time. There is no consistent pattern or trend in the data. A few animals were slightly more variable than usual in the test 1 h after phlebotomy (including the one that showed statistically subnormal performance). A few became more variable toward the end of the 30-day follow-up period (including the one that appeared statistically subnormal in the last follow-up session). In no case did any of the animals show any departure from normal behavior that could be attributed to aftereffects of blood loss.

DISCUSSION

The blood volume of humans is 79 ml/kg (±10%), or approximately 3950 ml for an individual weighing 50 kg (14). The standard volume given by human donors is 450 ml, which can be withdrawn every 8 weeks. This equates to approximately 11% of the total blood volume of a 50 kg human. Rhesus monkey blood volumes of from 44-77 ml/kg have been reported (1,9,13), with mean values of 54.1 ml/kg (1) and 60.9 ml/kg (3). Therefore, a single withdrawal of 10 ml/kg removes a greater proportion of blood volume (18%) than the standard human donor provides. However, a substantial safety factor is built into the practices for human blood donations to account for variation in size, weight, and other factors related to physical and physiologic fitness to donate without ill effects. Considerable care is taken to ensure that donors do not depart in a state that might negatively affect their performance of everyday tasks. If a given blood volume can be removed without negatively impacting the performance of the subjects, evidence is provided that potential negative effects of blood volume reduction have been avoided.

Previous research has shown that the PEP performance task is extremely sensitive to low-dose drug effects (3, 4). Effects graded with drug dose far larger than any changes seen in the present study have been observed while the monkeys continue performing without great increases in shock frequency. In the present study, none of the animals showed performance decrements sufficient to produce any increase in shock frequency (typically less than 1 per hour). The observed lack of any systematic or significant performance decrements clearly shows that large volume phlebotomy, such as that performed for blood transfusion donors, is unlikely to affect any behavioral measurement.

The case in which marginal increases in performance variability appeared 1 h after phlebotomy is more likely due to the phlebotomy procedures rather than to blood loss

per se. The case in which subnormal performance appeared 4 weeks after phlebotomy can more readily be attributed to normal drift in the performance or reduced frequency of testing (once per week rather than several times per week earlier in the experiment). This general absence of performance decrements negates the traditional view that removal of volumes of up to 10 ml/kg body weight results in weakness and clinically observable deficits. The standard for human blood donors is single phlebotomies of 450 ml. The minimum weight allowed for human donors is 50 kg (110 lb.). In a donor of this small stature, one unit of blood would represent 9 ml/kg, or 13% of the total blood volume. No restrictions for operation of motor vehicles are placed on human donors, leading to the conclusion that withdrawal of this volume will not affect motor coordination. Although extrapolations between humans and animals cannot be made with certainty, one could postulate that similar volume phlebotomies from nonhuman primates also would not affect motor performance. This theory is supported by this study in which phlebotomies of 10 ml/kg had no effect on the PEP performance of rhesus monkeys. In conclusion, phlebotomy of 10 ml/kg is safe for rhesus monkeys and will not significantly affect the results of subsequent performance testing.

References

1. Altman PL, Dittmer DS: Biology Data Book, Vol III (2nd Ed.). Federation of American Socieities for Experimental Biology, 1974, Bethesda, p. 1847.
2. Barnes DJ, Brown GC, Fractor BS: Differential effects of multiple and single irradiations upon the primate equilibrium function. *USAF School of Aerospace Medicine. 1971; USAFSAM-TR-71-1.* Brooks AFB, TX
3. Bender, M: Blood volume of the rhesus monkey. *Science* 1955;122:156.
4. Blick DW, Kerenyi SZ, Miller S, Murphy MR, Brown GC, Hartgraves S L: Behavioral toxicity of anticholinesterases in primates: Chronic pyridostigmine and soman interactions. *Pharmacol Biochem Behav* 1991;38:527-532.
5. Blick DW, Miller SA, Brown GC, Murphy MR: Behavioral toxicity of anticholinesterases in primates: Chronic physostigmine and soman interactions. *Pharmacol Biochem Behav* 1993;45(3):677-683.
6. Blick DW, Murphy MR., Brown GC, Hartgraves SL: Primate performance decrements following acute soman exposure: Failure of chemical countermeasures. *Pharmacol Biochem Behav* 1994;49(3):503-510.
7. Blick DW, Murphy MR, Brown GC, Yochmowitz MG, Fanton JW, Hartgraves SL: Acute behavioral toxicity of pyridostigmine or soman in primates. *Toxicol Appl Pharmacol* 1994;126:311-318.
8. Blick DW, Weathersby FR, Jr., Brown GC, Murphy MR: Behavioral toxicity of anticholinesterases in primates: Effects of daily repeated soman exposure. *Pharmacol Biochem Behav* 1994;48(3):643-649.
9. Bourne, G. H. Collected anatomical and physiological data from the rhesus monkey. In: The Rhesus Monkey, Bourne, G. H. (Ed), New York; Academic Press, 1975, p. 61.
10. Doctor BP, Blick DW, Caranto G, Castro CA, Gentry MK, Larrison R, Maxwell DM, Murphy MR, Schutz M, Waibel K, Wolfe AD: Cholinesterases as scavengers for organophosphorus compounds: Protection of primate performance against soman toxicity. *Chemico-Biological Interactions* 1993;87:285-293.
11. Doctor BP, Blick DW, Gentry MK, Maxwell DM, Miller SA, Murphy MR, Wolfe AD: A pretreatment drug for organophosphate toxicity. In: Shafferman, A., and Velan, B. (Eds.), *Multidisciplinary Approaches to Cholinesterase Functions*, New York: Plenum, 1992, pp. 277-284.
12. Farrer DN, Yochmowitz MG, Mattsson JL, Lof NE, Bennett CF: Effects of benactyzine on an equilibrium and multiple response task in rhesus monkeys. *Pharmacol Biochem Behav* 1982;16:605-609.
13. Grauwiler J: Herz und Kreislauf der Saugetiere. Birkhauser Verlag, 1965, Basel, p.155.
14. Guyton AC: Textbook of Medical Physiology. W.B. Saunders Co., 1986, Philadelphia, p. 382-392.

15. Krise, GM and Wald, N: Hematological effects of acute and chronic experimental blood loss in the Macaca mulatta monkey. *Am J Vet Res* 1959;20:1081-1085.

16. Mandell CP, George JW: Effect of repeated phlebotomy on iron status of rhesus monkeys (Macaca mulatta). *Am J Vet Res* 1991;52(5):728-733

17. Miller SA, Blick DW, Kerenyi SZ, Murphy MR: Efficacy of physostigmine as a pretreatment for organophosphate poisoning. *Pharmacol Biochem Behav* 1993;44(2):343-7.

18. Murphy MR, Blick DW, Dunn M, Fanton JW, Hartgraves SL: Diazepam as a treatment for nerve agent poisoning. *Aerosp Med* 1993;64:110-115.

19. Patrick RP, Rahe AJ, Lof, NE: Nuclear survivability/vulnerability of aircrews: an experimental approach. *USAF School of Aerospace Medicine. 1981; USAFSAM-TR-81-1.* Brooks AFB, TX

20. Personal Communication, Dr. Tom Butler, Southwest Foundation for Biomedical Research, San Antonio, TX.

21. Personal Communication, Dr. I. Kozlovskaya, Institute of Biomedical Problems, Moscow, Russia.

22. Personal Communication, Dr. Boris Lapin, Institute of Medical Primatology, Sochi, Adler, Russia.

23. Sherry CJ, Blick DW, Walters TJ, Brown GC, Murphy MR: Lack of behavioral effects in non-human primates after exposure to ultrawide band electromagnetic radiation in the microwave frequency range. *Radiat Res* 1995: 143(1), 93-97.

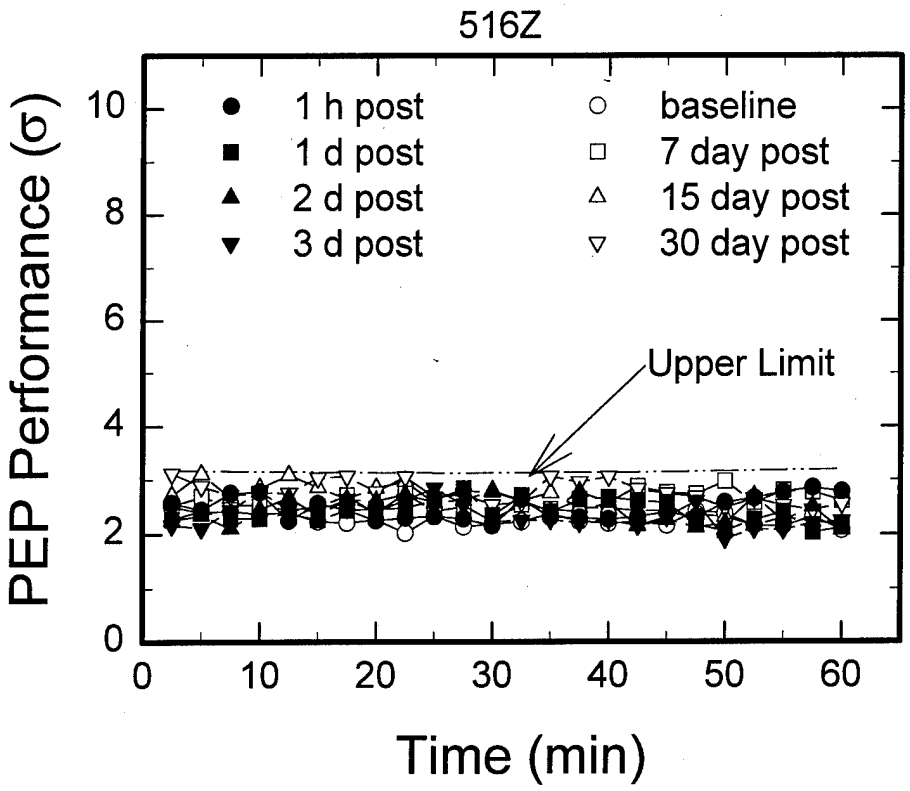
24. Wolfe AD, Blick DW, Murphy MR, Miller SA, Gentry MK, Hartgraves SL, Doctor BP: Use of cholinesterases as pretreatment drugs for the protection of rhesus monkeys against soman toxicity. *Toxicol Appl Pharmacol* 1992;17:189-193.

25. Yochmowitz MG, Patrick RP, Jaeger R, Barnes DJ. Protracted radiation-stressed primate performance. Aviat Space Environ Med 1977;48(7):598-606.

Figure Legend

Figures 1-2: Monkey Performance of the Primate Equilibrium Performance (PEP) Task.

The identification number of each animal is shown above the top panel in each figure. The top panel shows the performances in each of the recorded sessions (1h to 30d post-phlebotomy), plus a baseline value (the average of 5 pre-phlebotomy performances) and the statistical upper limit of normal performance ($p = .95$, $\alpha = .05$) based on the mean and variability of the 5 baseline sessions. In the lower panel, a mean ($\pm$ s.e.m) for each of the sessions in the top panel is plotted as a function of time relative to the phlebotomy.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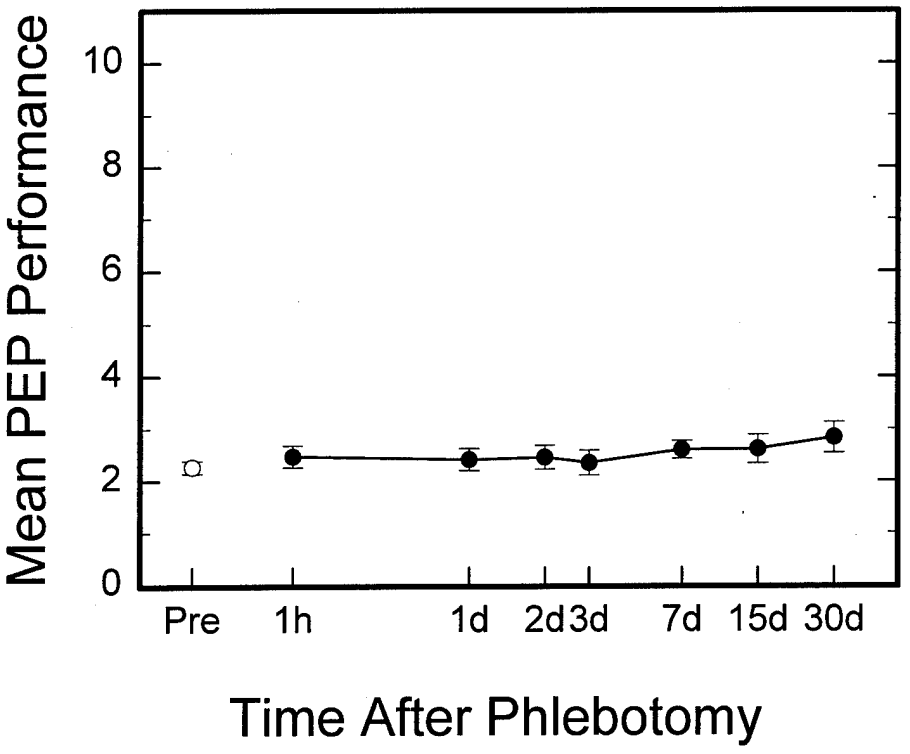
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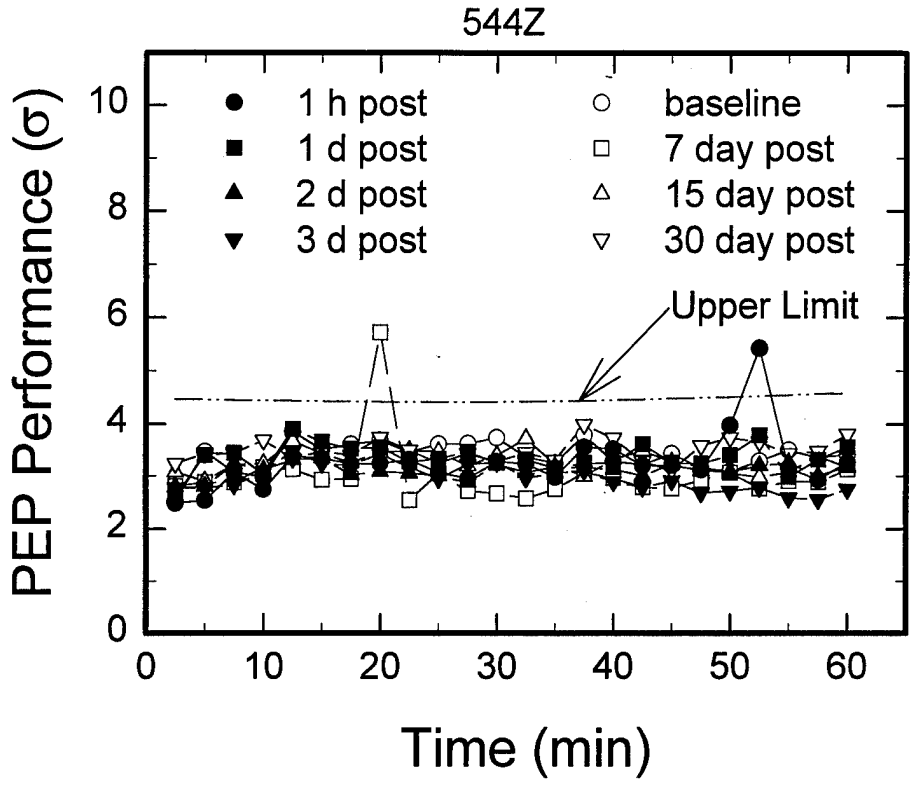
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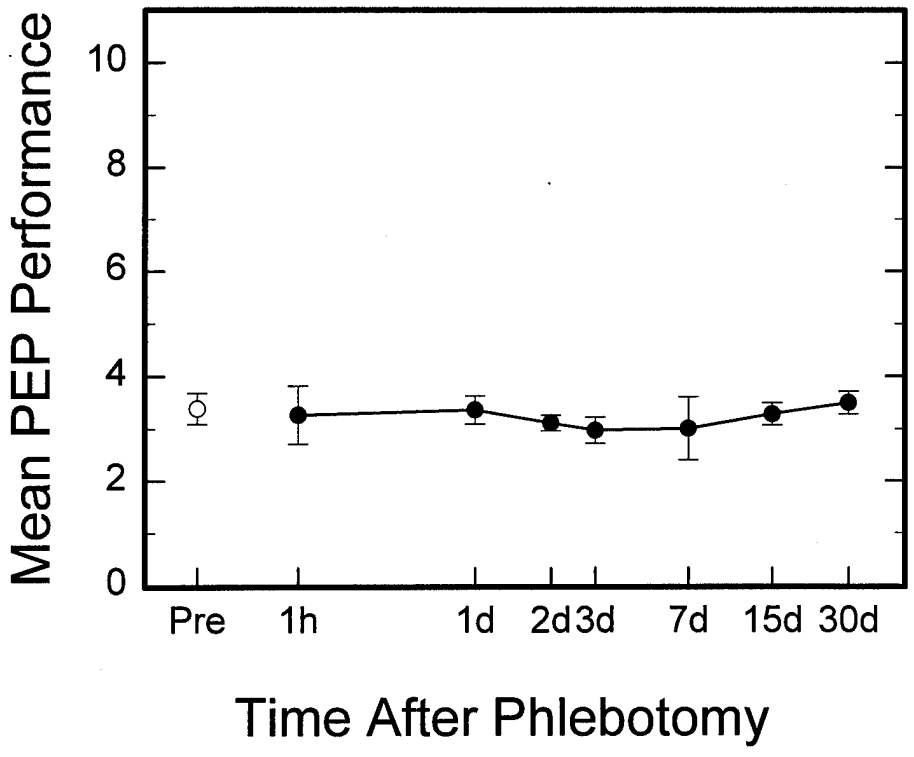
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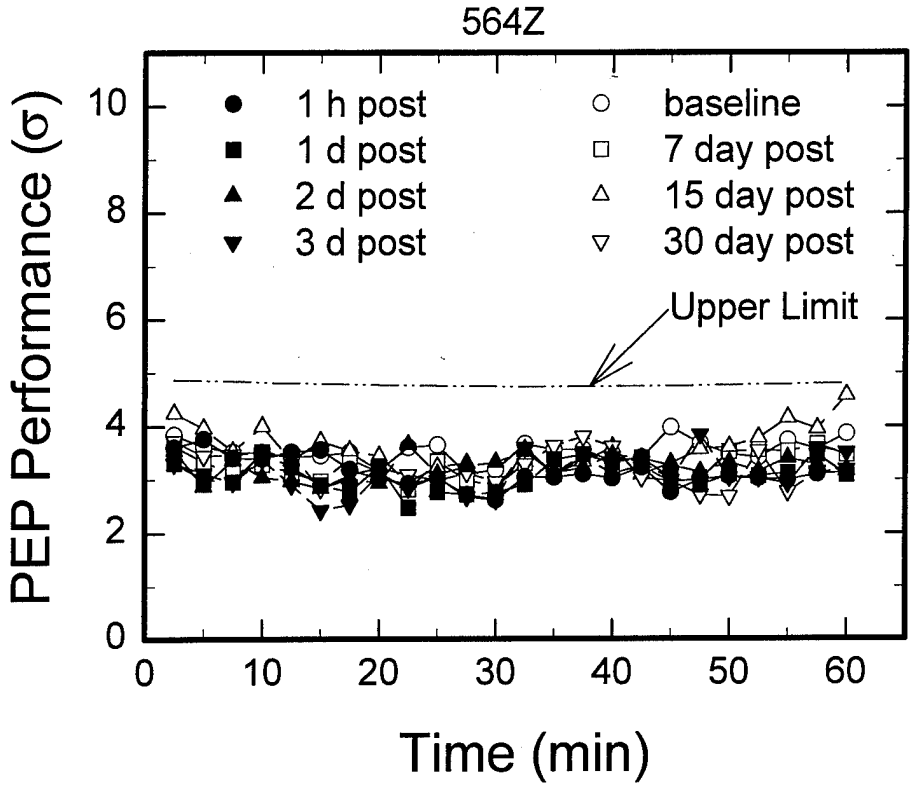
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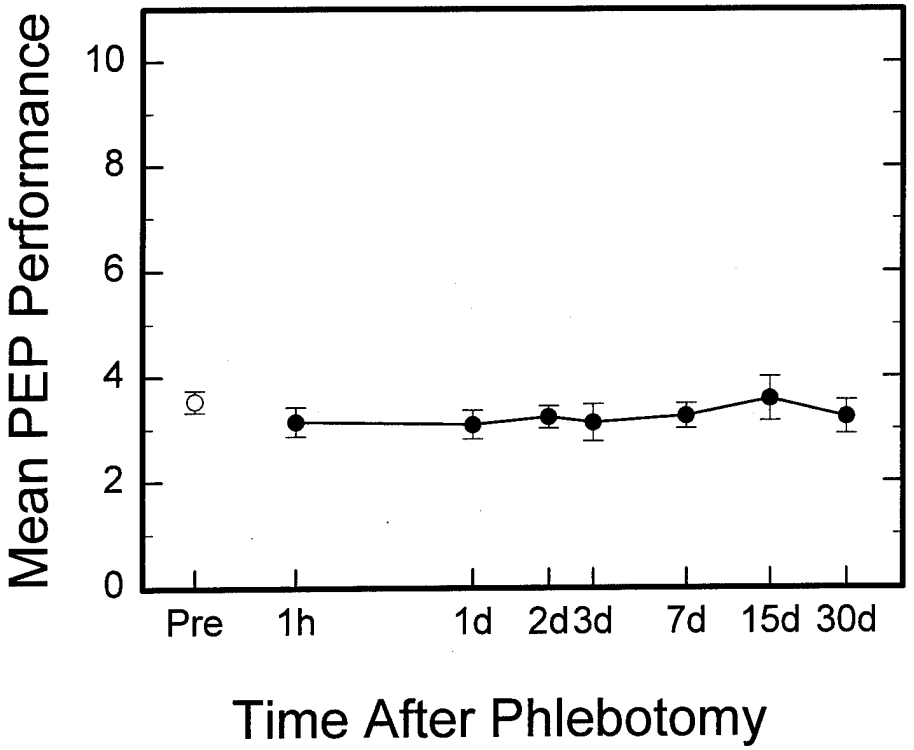
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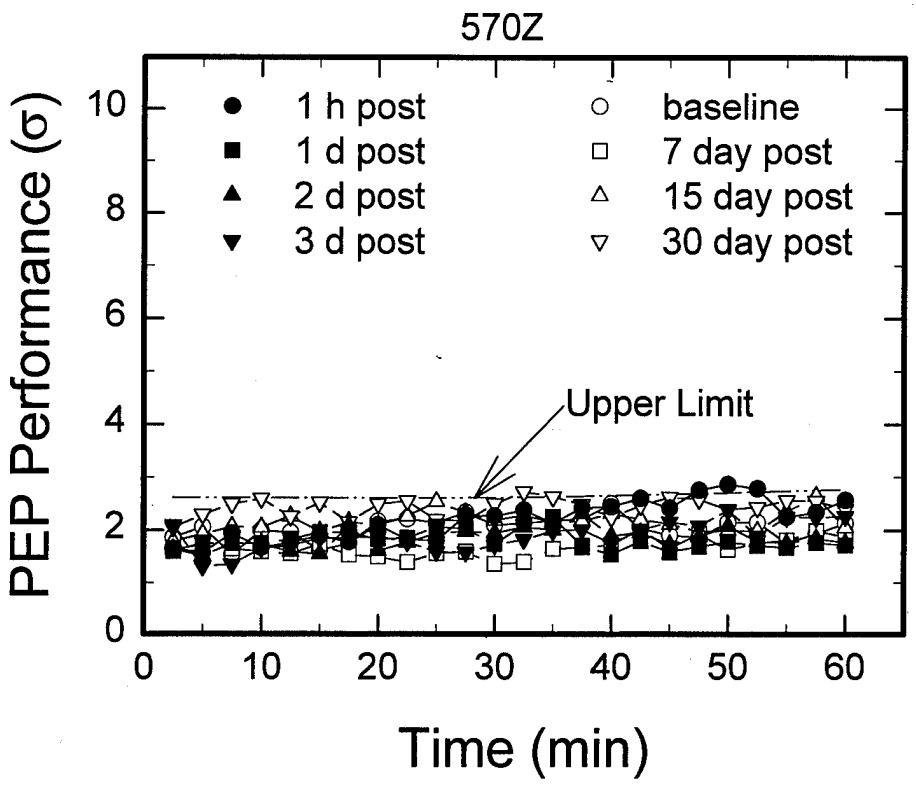
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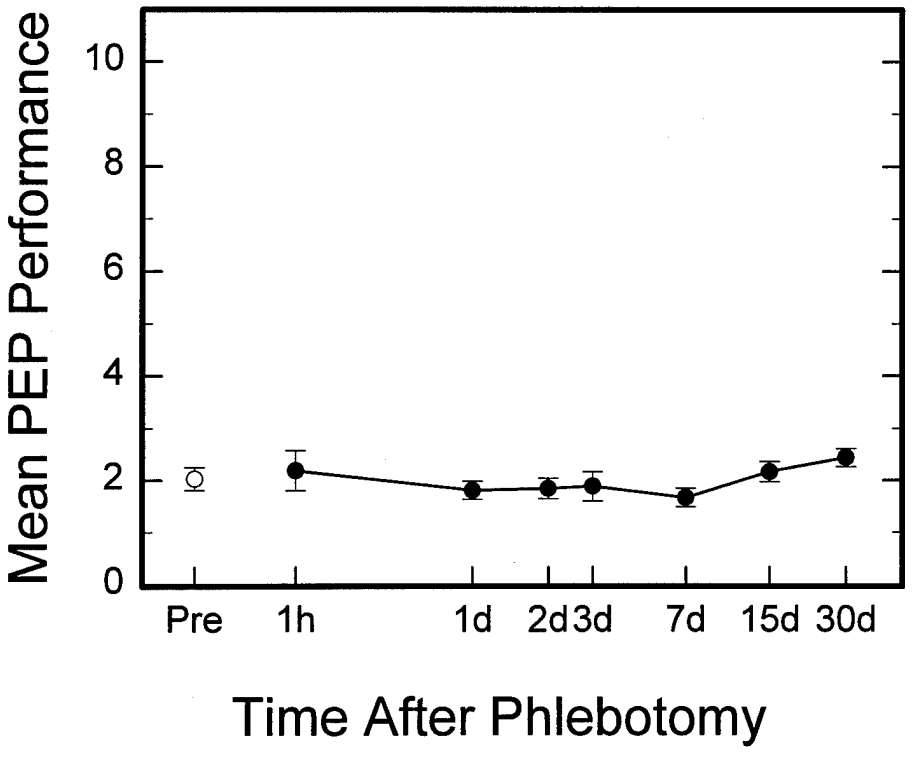
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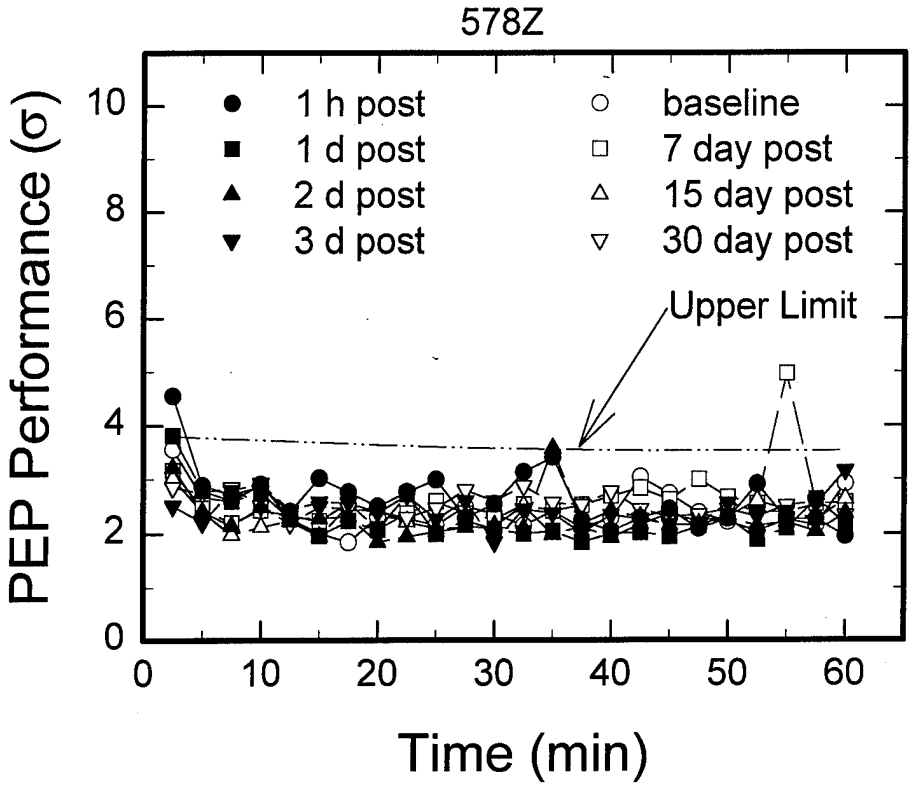
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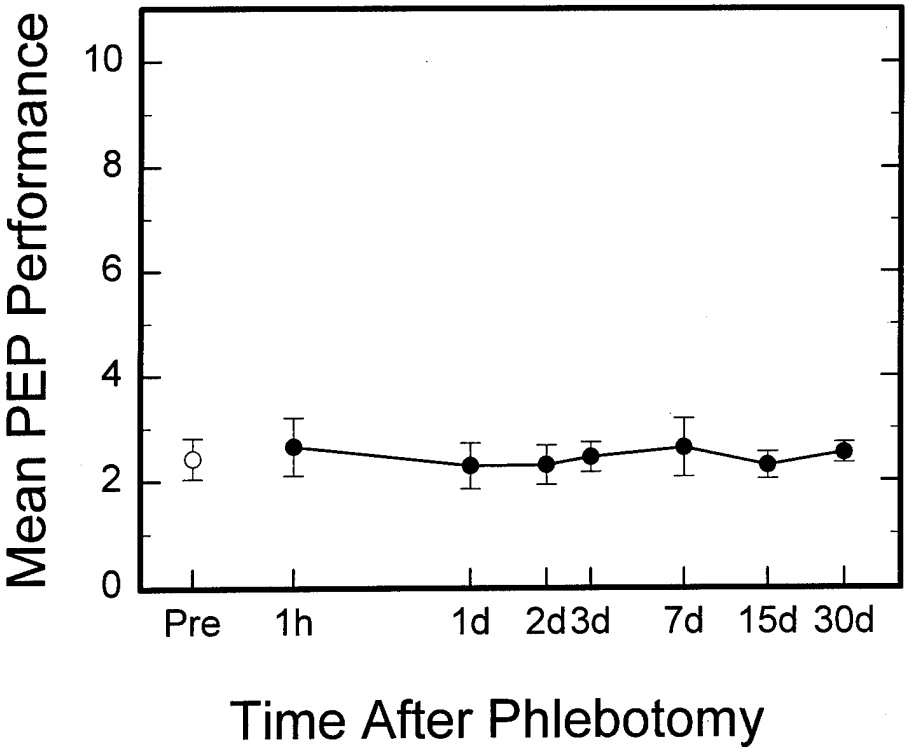
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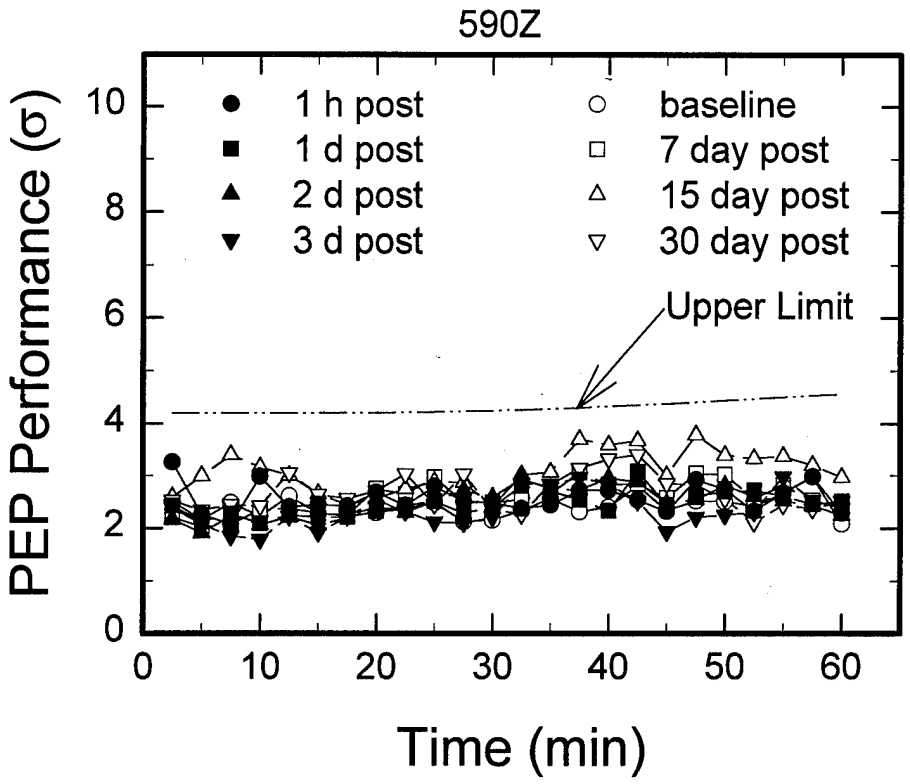
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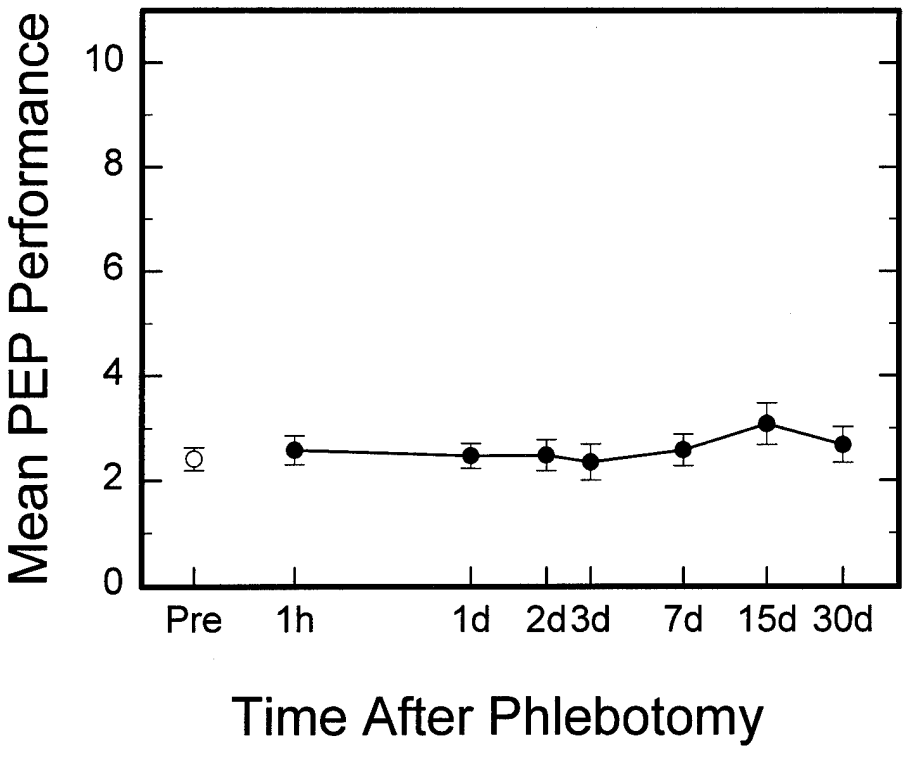
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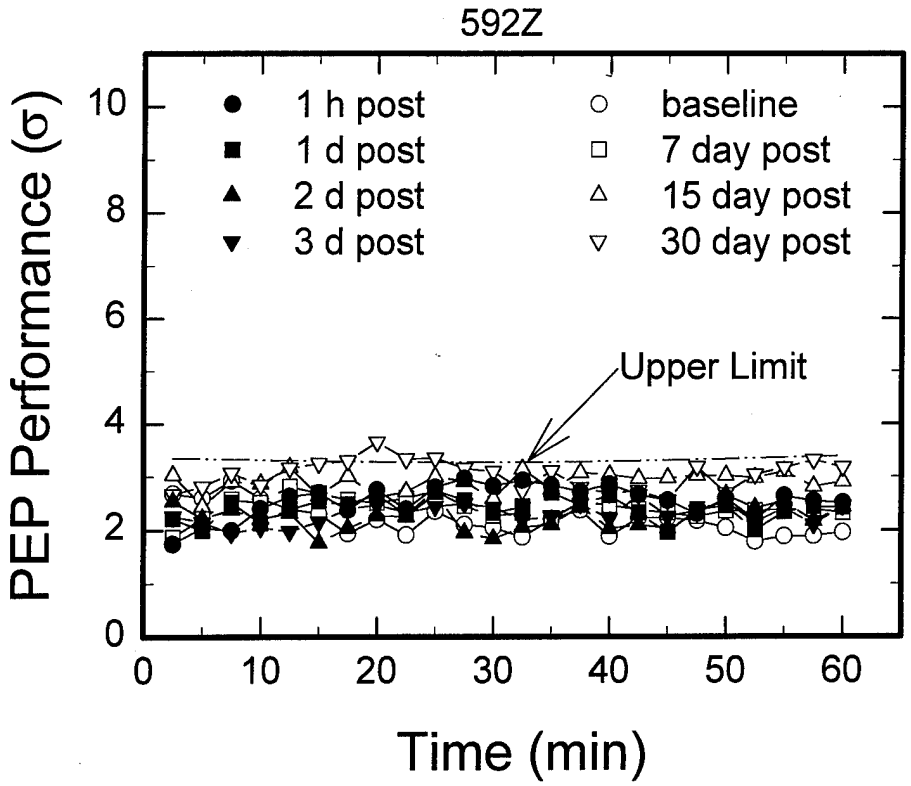
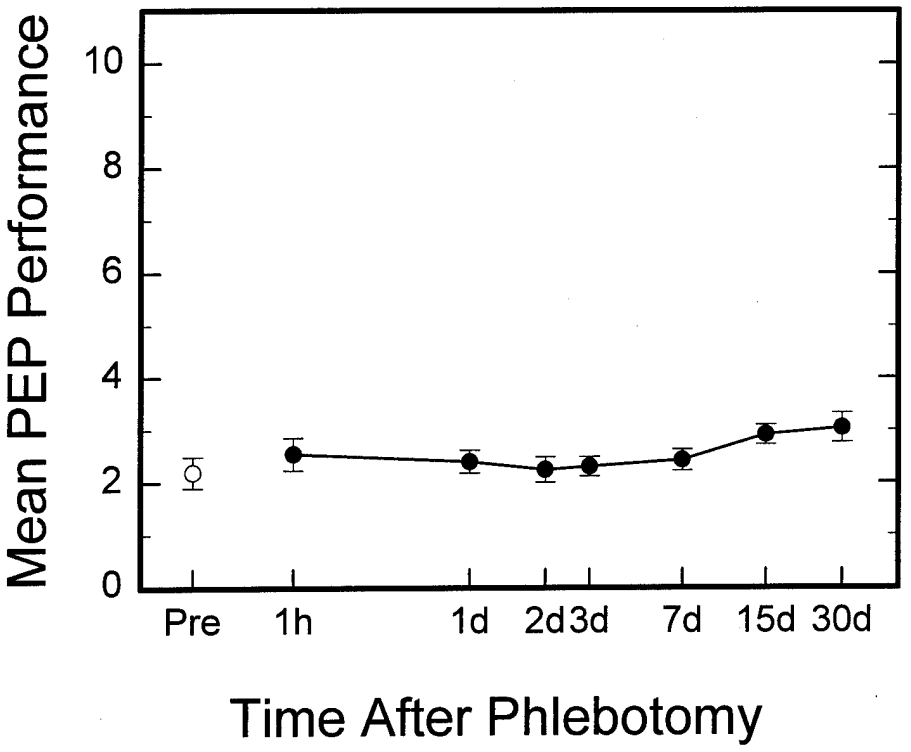
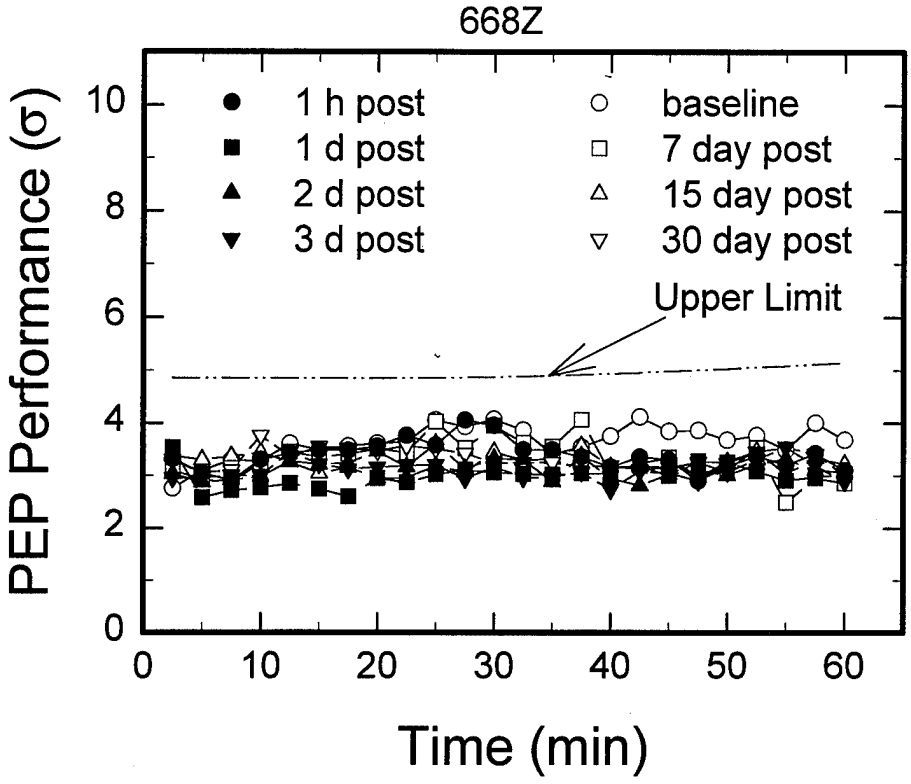
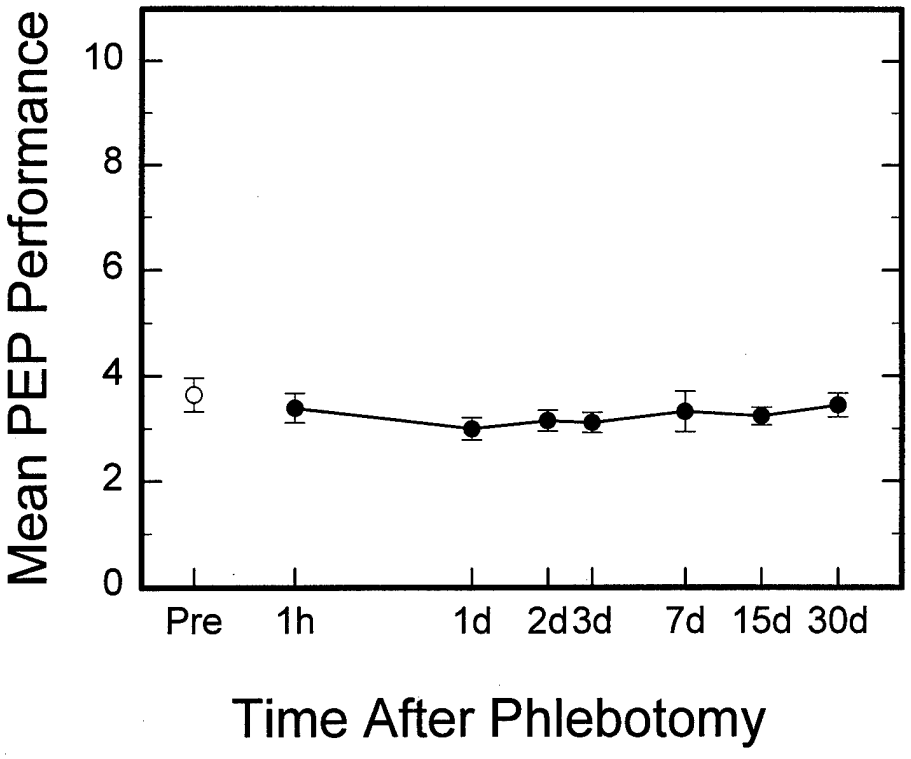
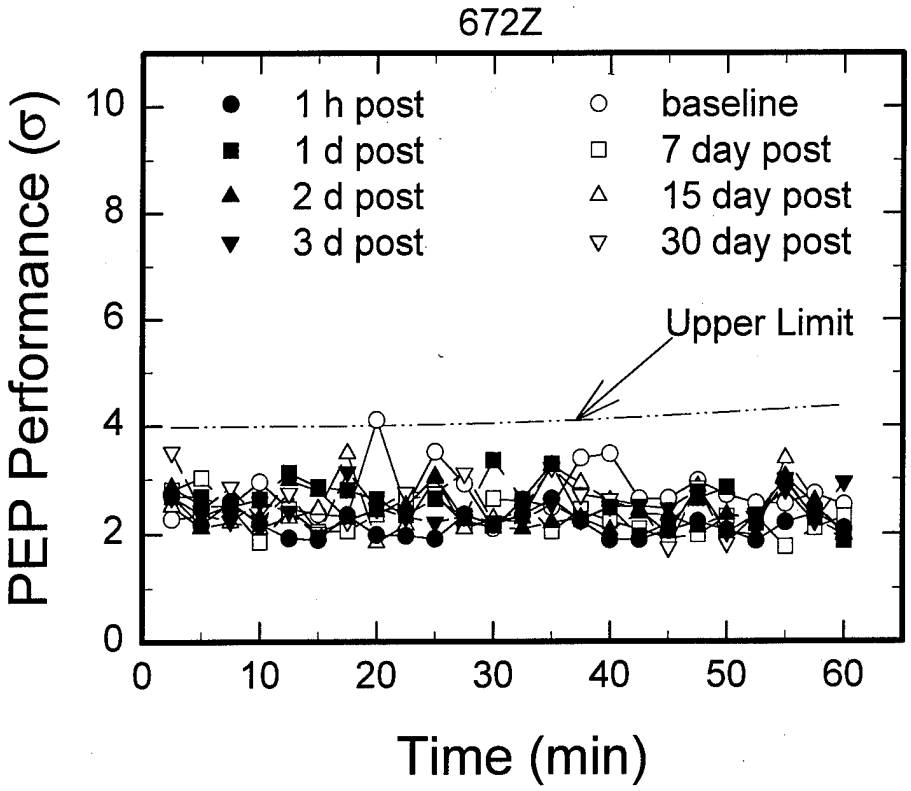
30d
Time After Phlebotomy

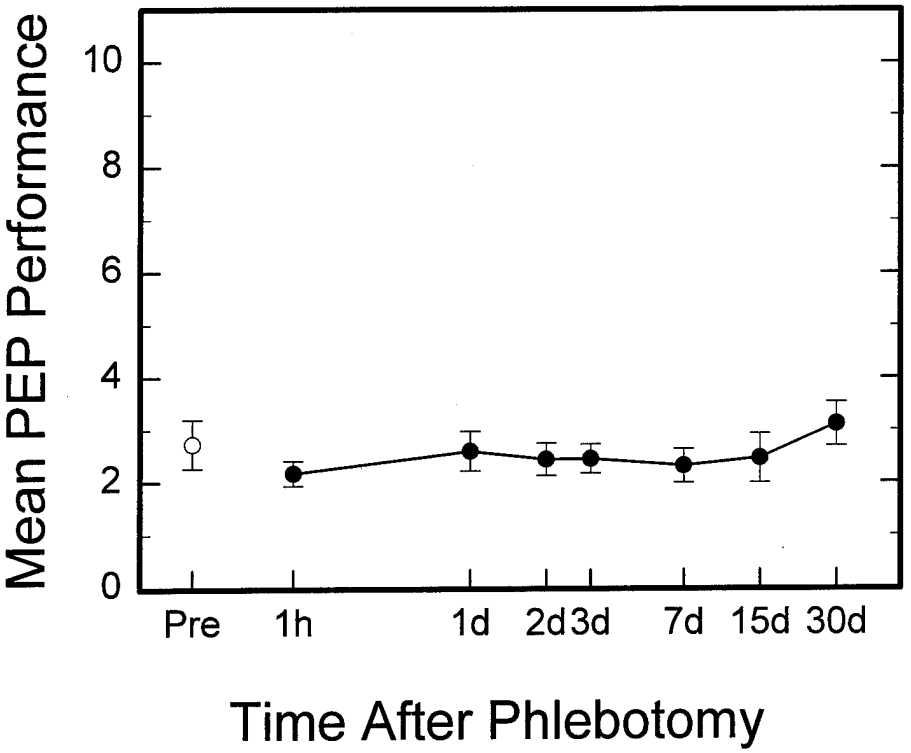

592Z
PEP Performance (σ)
1 h post
1 d post
2 d post
3 d post
baseline
7 day post
15 day post
30 day post
Upper Limit
0
2
4
6
8
10
0
10
20
30
40
50
60
Time (min)

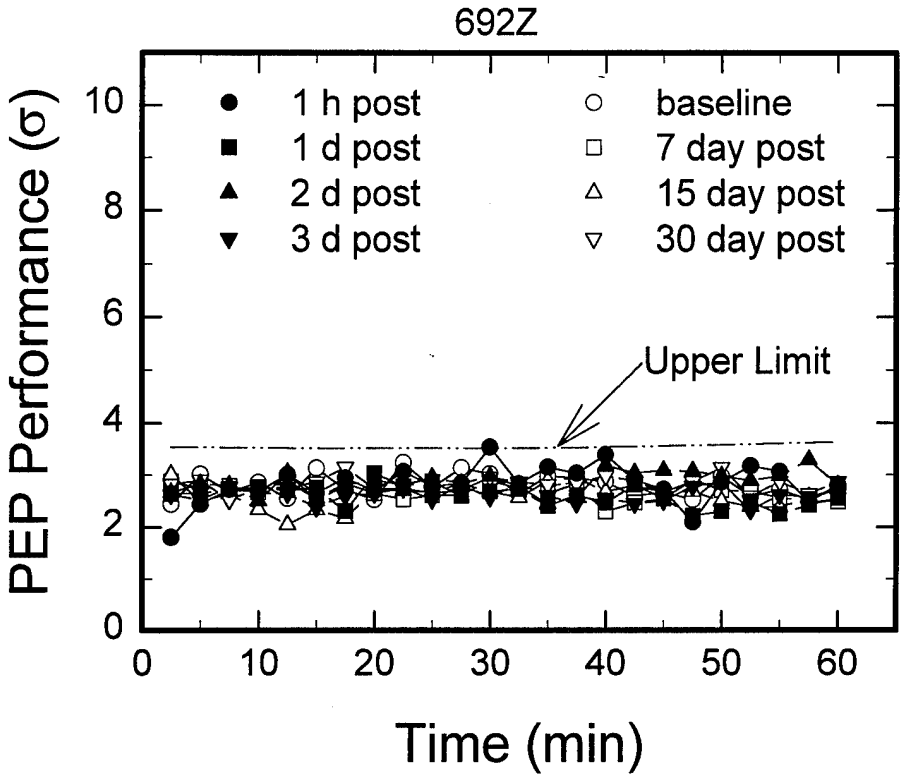

Mean PEP Performance
0
2
4
6
8
10
Pre
1h
1d
2d
3d
7d
15d
30d
Time After Phlebotomy

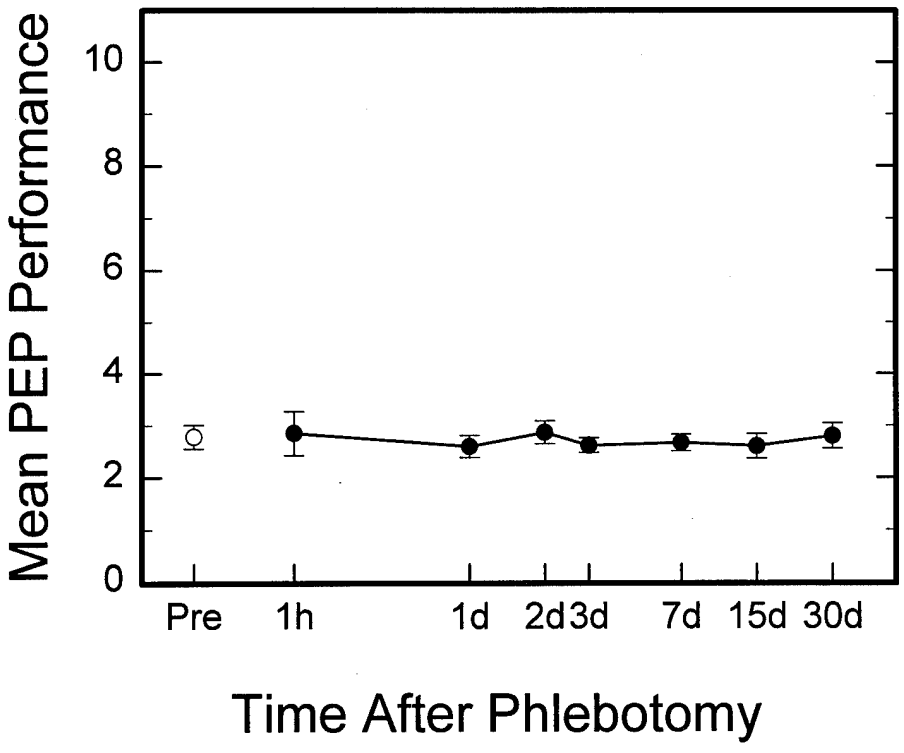

668Z
PEP Performance (σ)
1 h post
1 d post
2 d post
3 d post
baseline
7 day post
15 day post
30 day post
Upper Limit
0
2
4
6
8
10
0
10
20
30
40
50
60
Time (min)

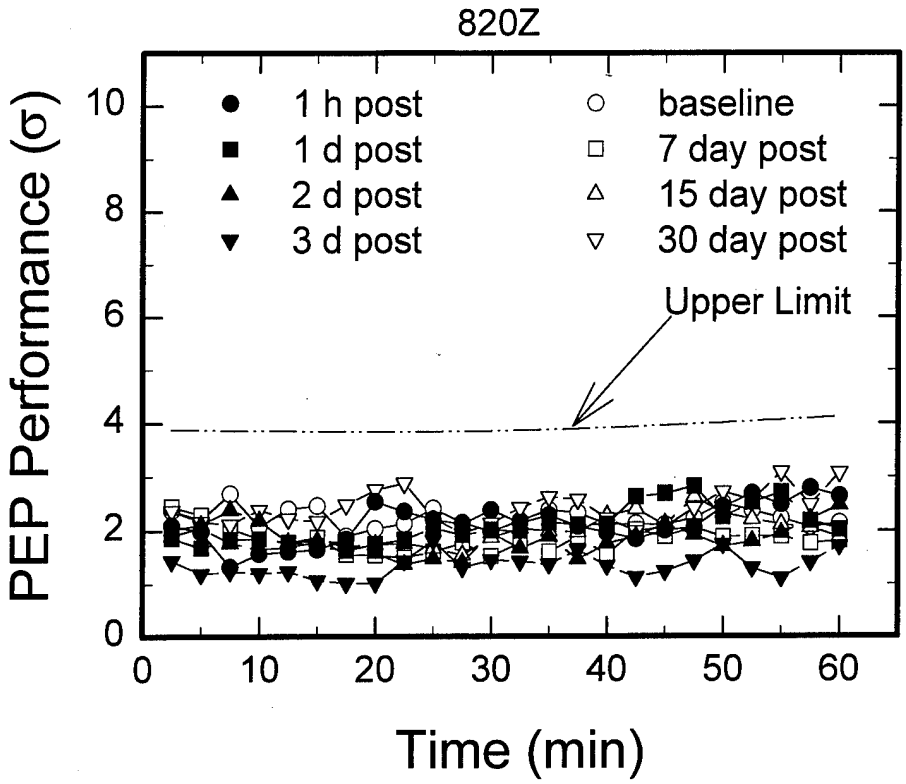

Mean PEP Performance
0
2
4
6
8
10
Pre
1h
1d
2d
3d
7d
15d
30d
Time After Phlebotomy

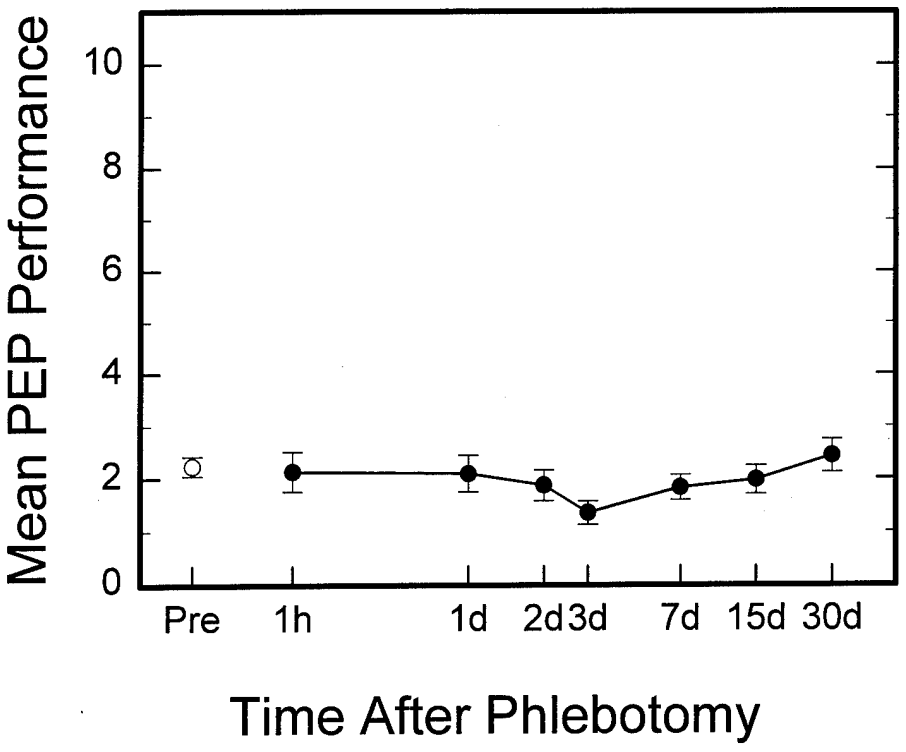

672Z
PEP Performance (σ)
1 h post
1 d post
2 d post
3 d post
baseline
7 day post
15 day post
30 day post
Upper Limit
0
2
4
6
8
10
0
10
20
30
40
50
60
Time (min)

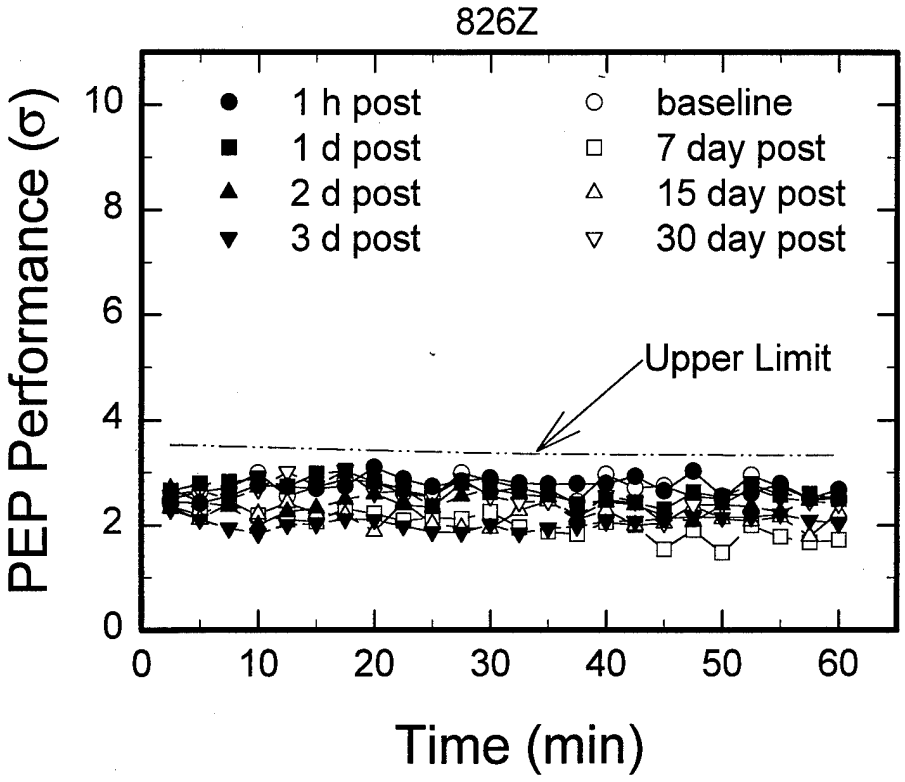

Mean PEP Performance
0
2
4
6
8
10
Pre
1h
1d
2d
3d
7d
15d
30d
Time After Phlebotomy

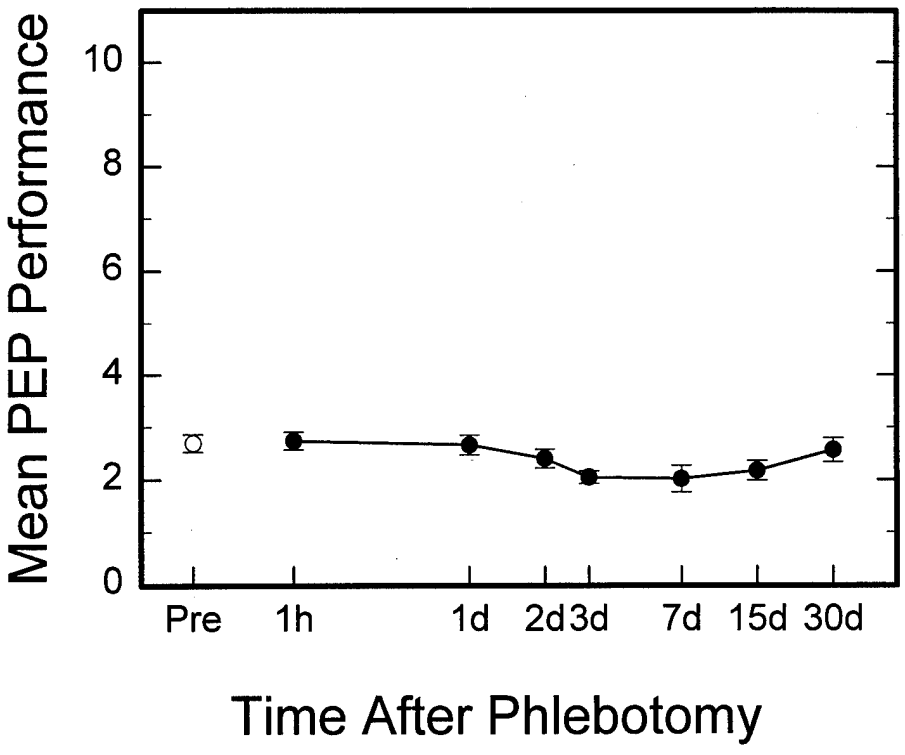

692Z
PEP Performance (σ)
1 h post
1 d post
2 d post
3 d post
baseline
7 day post
15 day post
30 day post
Upper Limit
0
2
4
6
8
10
0
10
20
30
40
50
60
Time (min)


Mean PEP Performance
0
2
4
6
8
10
Pre
1h
1d
2d
3d
7d
15d
30d
Time After Phlebotomy


820Z
PEP Performance (σ)
1 h post
1 d post
2 d post
3 d post
baseline
7 day post
15 day post
30 day post
Upper Limit
0
2
4
6
8
10
0
10
20
30
40
50
60
Time (min)


Mean PEP Performance
0
2
4
6
8
10
Pre
1h
1d
2d
3d
7d
15d
30d
Time After Phlebotomy


826Z
PEP Performance (σ)
1 h post
1 d post
2 d post
3 d post
baseline
7 day post
15 day post
30 day post
Upper Limit
0
2
4
6
8
10
0
10
20
30
40
50
60
Time (min)


Mean PEP Performance
0
2
4
6
8
10
Pre
1h
1d
2d
3d
7d
15d
30d
Time After Phlebotomy

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